Space Weather Technical Forecast

Issued on Sunday, 19 November 2023 at 13:30 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

---

Space Weather Forecast Headline: Increasing chance of M-Class flares and R1/Minor Radio Blackouts. Chance of G1/Minor Geomagnetic activity peaking Day 2 and a further risk Day 4.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate over the past 24 hours, with the background level X-ray flux recorded at GOES16 at low C-class throughout. The largest flare was an impulsive M1.2 at 18/1644UTC, with a second similar flare observed at 18/2234UTC. These flares appear to have emanated from a large region which is becoming visible on the northeastern limb and which may form part of the wider sunspot region AR3490.
There are three sunspot regions on the Earth-facing disc, with Ex-AR3486 having rotated off the disc over the last 24 hours. The largest group is AR3490 (Eai/Beta-Gamma), in the northeast, which continues to emerge from the limb. This group may yet be split as further rotation reveals more detail, however for now it appears as a large region with a large north-south span and a broad area of plage. Newly numbered AR3491 (Hsx/Alpha), a unipolar spot, lies at a distance to the south of this group.

There have been numerous CMEs observed on imagery over the last 24 hours, with the region narrowly behind the northeastern limb responsible for a large proportion of these, although no effects are expected to be felt at Earth. A CME was observed to the southeast on LASCO imagery around 19/0200 UTC and is attributed to a prominence eruption, seen lifting off on AIA-304 around 19/0100 UTC. This was followed by a small filament lift-off from the southeast disc around 19/0200UTC. A slow ejection was also observed just beyond the northwest limb around 19/0300 UTC, but appears to have been largely reabsorbed. Although no Earth-directed components are expected from these recent CMEs, we are currently awaiting the output from Enlil modelling.

Solar Wind / Geomagnetic Activity: Solar winds, as measured by ACE and DSCOVR at L1, have remained at slow-ambient levels but have risen slightly since midnight and are now around 350 km/s. The solar wind density has been below average. The IMF was steady at or below 5nT, with the north-south weakly fluctuating with a range of +/-5nT. The phi angle has been predominantly negative (towards the Sun) with very brief positive (away from the Sun) intervals.

The net result of the above solar wind measures was for Quiet (Kp 0-2) geomagnetic activity throughout.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux remained at Background levels.

GOES16 high energy (greater than 2MeV) electron flux was at Moderate levels with a peak of 400pfu at 18/1825 UTC, after 18/2230 UTC flux declined to mostly background levels but has been gradually rising in recent hours. The associated 24-hour fluence has declined slightly and remains below the Active threshold (1e8 integrated pfu) threshold. The fluence observation at 19/0001UTC was 1.31e7 integrated pfu.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is likely to remain Moderate through the period with further isolated M-class flares, these most likely to come from regions presently just beyond the northeastern limb that are expected to rotate onto the visible disc in the coming days.

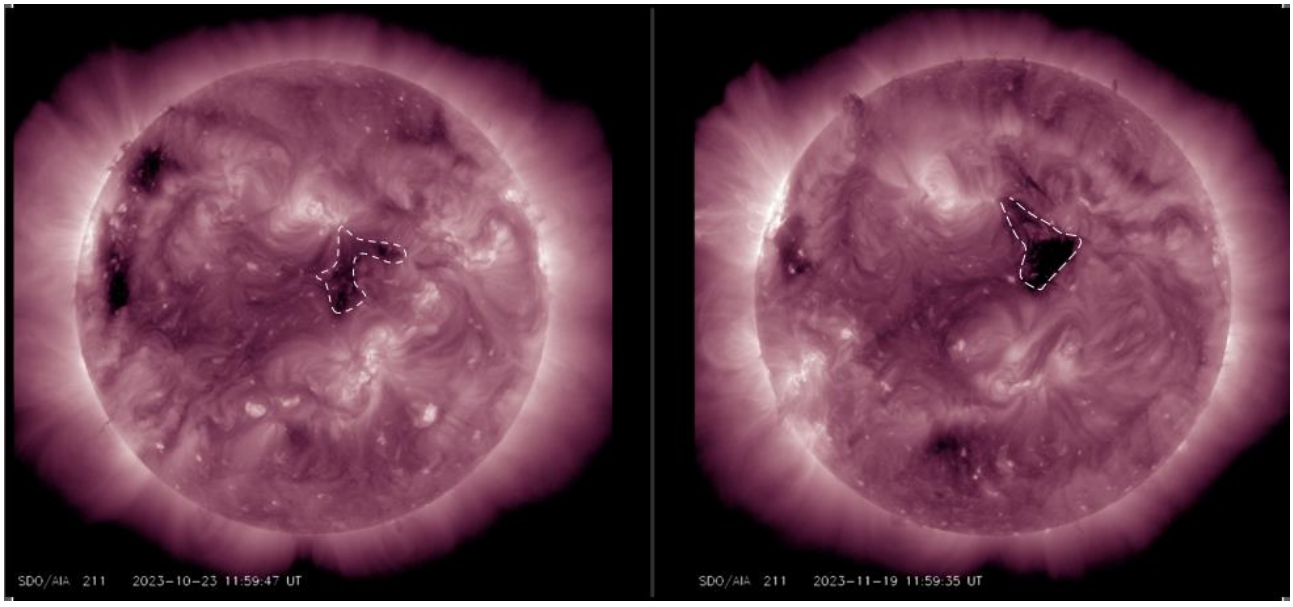
Solar Wind / Geomagnetic Activity: There is one CME in the current forecast - the central filament eruption from 16/0100 UTC. This is due either late Day 1 (19 Nov) or more likely in the UTC morning of Day 2 (20 Nov) with an associated slight chance of a G1/Minor Geomagnetic Storm. Activity is expected to otherwise be mostly Quiet to Unsettled (Kp 0-3) until the anticipated onset of a coronal hole HSS on Day 4 (22 Nov) which may see a greater chance of generating a G1/Minor Geomagnetic Storm.

Solar winds are expected to remain initially at or close to slow-ambient levels, with brief enhancement following the CME arrival late Day 1 or Day 2. A more significant increase is expected Day 4 following the onset of a HSS from CH73/+ with winds increasing to 500 km/s or more.

Energetic Particles / Solar Radiation: GOES16 high energy proton flux is expected to remain at Background levels.

GOES16 High energy electron flux is expected to be mostly Moderate, perhaps seeing diurnal peaks at High levels during the period. The potential CME arrival and associated geomagnetic activity may suppress observed flux levels with a slight recover Day 3 (21 Nov). The associated 24-hour electron fluence is expected to remain below the Active (1e8 integrated pfu) level, but perhaps with an eventual increasing trend in response to a CME arrival late Day 1 (19 Nov) or Day 2 (20 Nov).

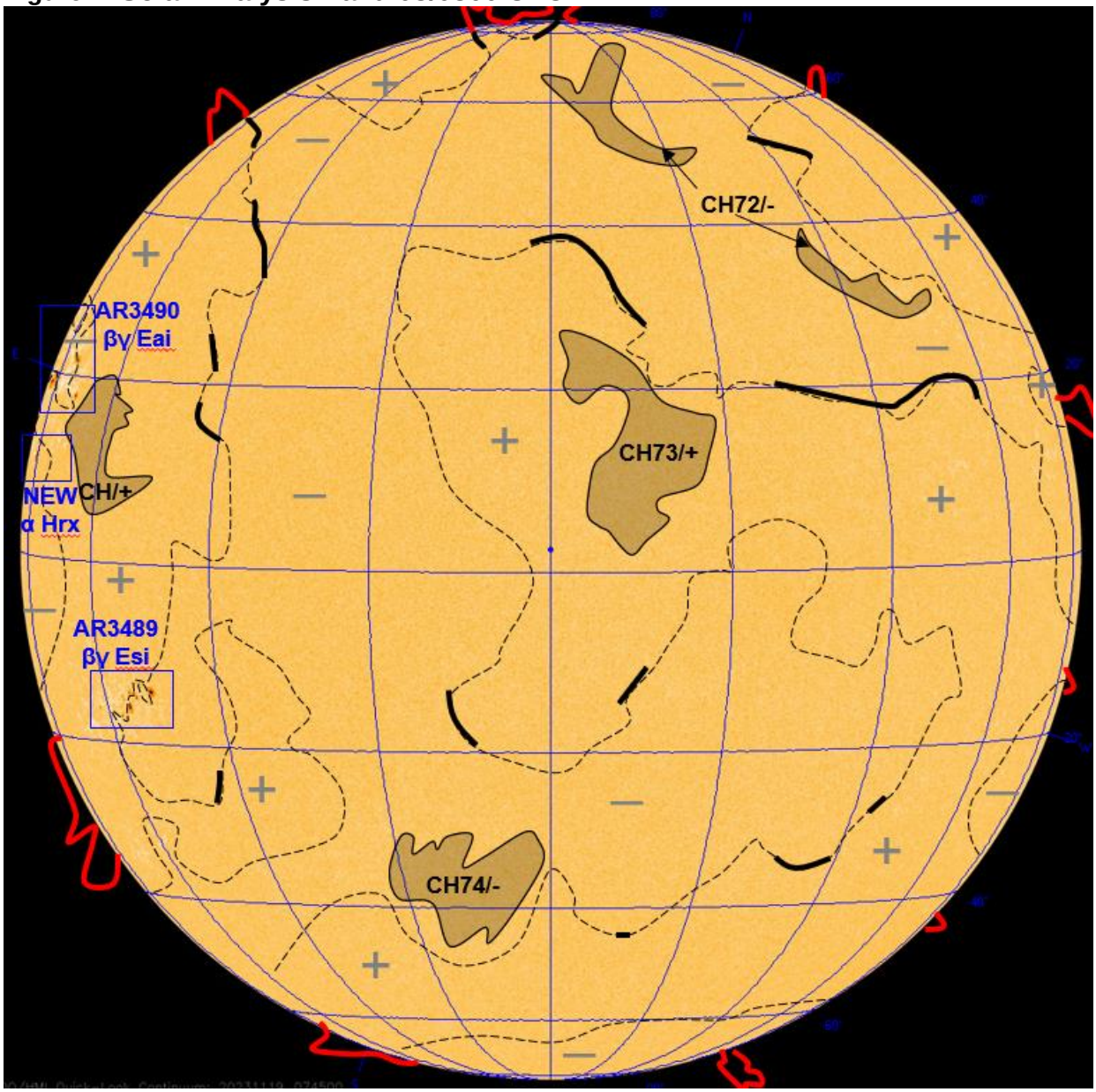
Figure 1. SDO AIA-211 imagery showing CH73/+ feature on this rotation (right) compared to last rotation (left).



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Figure 2. Solar Analysis Valid 08/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Geomagnetic Storms:

There is one Earth-directed CME that features in the current forecast, the 16/0100 UTC filament eruption from near centre-disc. Despite extensive analyses, the onset time of this feature remains low confidence, although confidence as to a portion of the ejecta lying on the Sun-Earth line is much higher. A most likely arrival remains in the UTC morning of Day 2 (20 Nov) but with a broad spread of roughly +/-12 hours suggested by the MOSWOC Enlil ensemble.
Much of the CME activity seen on available coronagraph imagery over the past 24 hours appears to emanate from arriving active regions which presently lie narrowly behind the northeastern limb. This is likely to play an increasing role in the risk of geomagnetic activity through the period should activity persist, but more so beyond the forecast period as the active regions are in a more Earth-facing location on the visible disc. Other CMEs observed in the early hours of Day 1 (19 Nov) are visible to the south on coronagraph imagery and may have some Earth-directed component, although the modelling of these features through Enlil is ongoing.
There are a number of filaments on the disc which have the potential to disrupt and lift-off, perhaps producing Earth-directed CMEs. Although this is low confidence and does not contribute to the existing probabilities.

Solar winds are expected to remain at largely slow-ambient levels, with Enlil providing a good steer over initially. CH73/+, currently lying close to the equator may influence the geomagnetic forecast from Day 4 (22 Nov) with the onset of a HSS and associated enhancement. On the previous rotation, this features was at a similar longitude and produced winds of around 450-500 km/s. On this rotation, the features is visually darker and more pronounced on AIA-0211 implying a faster emanating wind at elevated levels, in excess of 500km/s.

Overall, geomagnetic activity is expected to be initially Quiet (Kp 0-1) with a chance of Unsettled (Kp 3) or Active (Kp 4) intervals and a slight chance of a G1/Minor Geomagnetic Storm (Kp 5) upon arrival of the 16 Nov CME. Beyond this, activity is expected to return to Quiet to Unsettled levels (Kp 0-3). Although we are nearing the winter solstice, positive features are still narrowly more potent than negative, and this coupled with the intensification of CH73/+ results in an increased chance of Active intervals and a chance of a G1/Minor Geomagnetic storm on Day 4.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	10	20	5	30
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
16/1100	Partial	Filament Eruption	NW Central	400 km/s	20/0600 UTC	Onset time low confidence.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Figure 3: MOSWOC Enlil and Ensemble showing arrival time of CME 19-20 Nov. Considered poor guidance for arrival of HSS late in period.

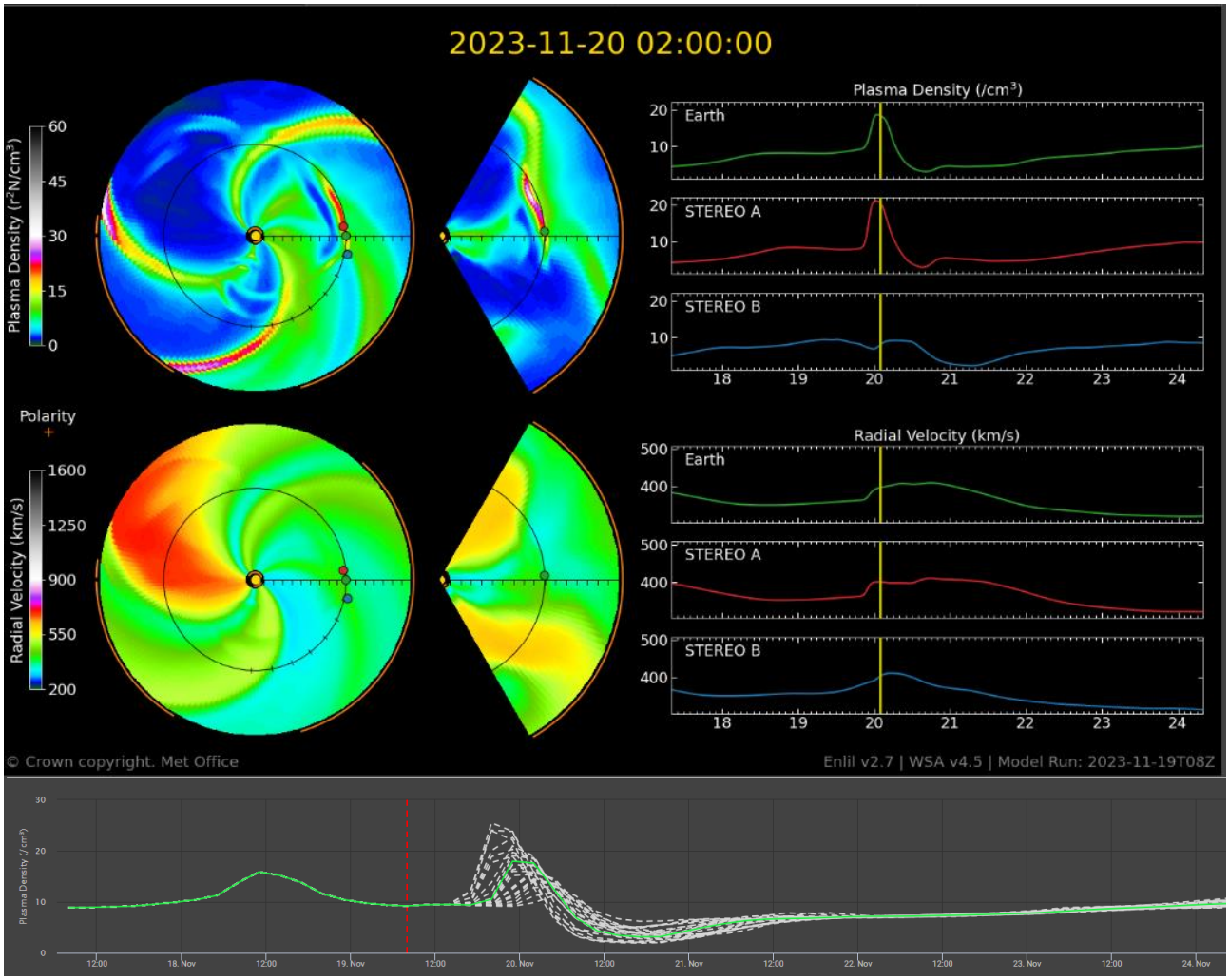
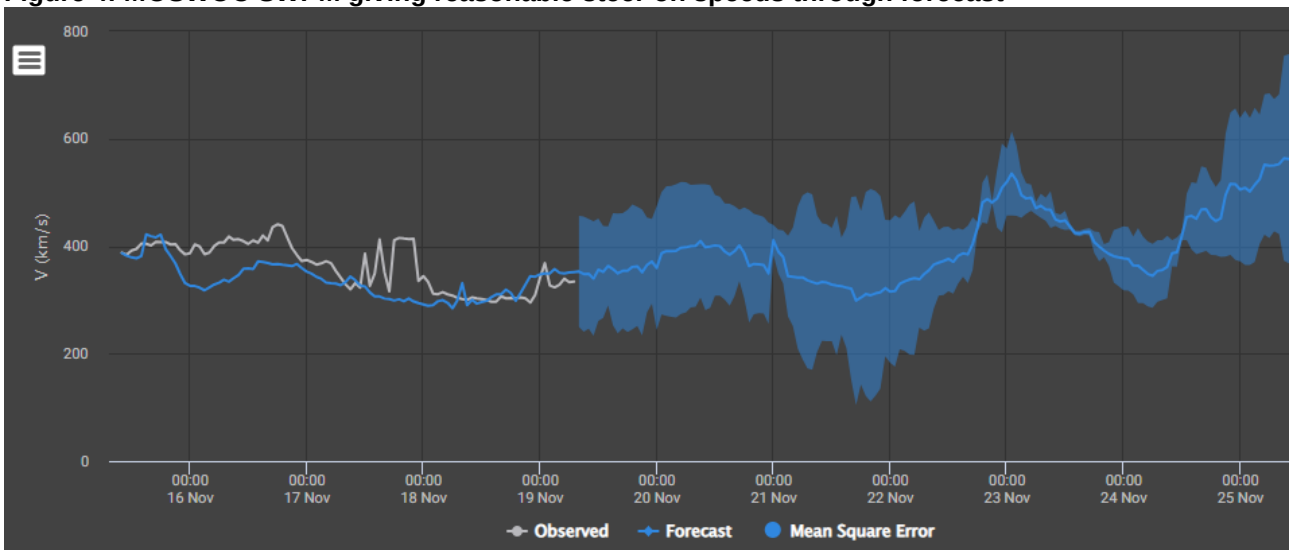


Figure 4: MOSWOC SWPM giving reasonable steer on speeds through forecast



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Radio Blackouts - X-Ray Flares:

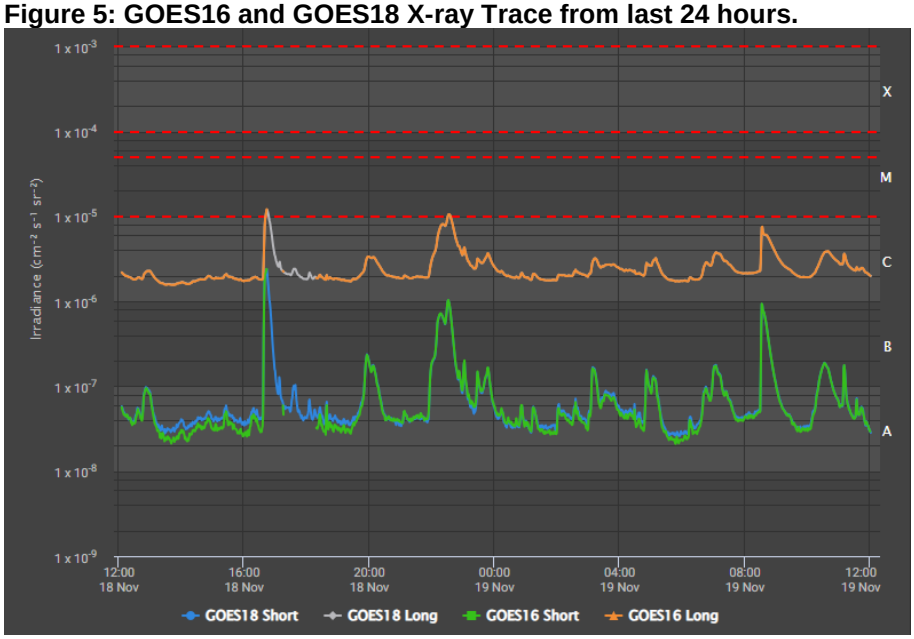
There are currently three regions on the visible disc, all of which lie in the eastern hemisphere. AR3489 (Esi/Beta-Gamma) is currently the most magnetically complex region on the disc and continues to see ready growth and decay of intermediate spots set within a broader area of plage. AR3490 (Eso/Beta-Gamma) continues to emerge from the northeastern limb and is characterised by a series of maturing spots within a bright area of plage and a large north-south span. This latitudinal extent may result in the group being split once further rotation reveals more detail. The final region on the disc, AR3491 (Hsx/Alpha) is an unremarkable unipolar spot to the south of AR3490.

Far-sided seismic analysis suggests the approach of one or more new or returning regions over the forecast period, with bright areas beyond the eastern limb apparent on AIA-0094 and in the looping of AIA-0171. The recent M-flares from the northeastern limb have been attributed to one of these emerging regions.

The observed 10.7cm Penticton flux showed a recovery to 127 sfu at after reaching a nadir of 116 sfu on Thursday 16 November - itself the lowest such value since 29 November 2022 and reflective of the almost spotless disc at that time. This value is expected to increase over the coming days as further regions rotate onto the solar disc across the eastern limb. The emergence of these regions as well as the continued development and westward transit of regions on the visible disc contribute to the increased probability of M-class flares and R1/Minor Radiation Storm events in the coming days.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	40	50	50	50
Very Active	R3 to R5 X Class	No	1	1	1	1

Figure 5: GOES16 and GOES18 X-ray Trace from last 24 hours.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux observed by GOES16 is currently at Background levels.

The anticipated arrival of at least one large and complex region over the eastern solar horizon over the coming days has resulted in a relative increase in the risks of a S1/Minor Solar Radiation Storm compared with mid-month. This risk remains nominal until any significant groups approach the western solar hemisphere, which is not expected during the forecast period. There are no significant off-going regions offering any additional nor diminishing contribution to this risk.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

Electron flux levels are expected to remain at background with diurnal periods at Moderate, or possibly High levels. Following the arrival of a CME late Day 1 (19 Nov) or Day 2 (20 Nov) flux levels may be briefly suppressed, before recovering Day 3 (21 Nov). The onset of coronal hole HSS influence later Day 4 (22 Nov) may suppress flux levels towards the end of the period.
A rebound in fluence levels may show at GEO towards midweek UTC in the wake of the CME, with this likely to again be attenuated by a HSS from CH73/+ through the course of Day 4.
CH73/+ is likely to be the most significant feature in terms of electron flux and fluence in the forecast, however its effects will likely not be felt until beyond the forecast period.

Uncertainties surrounding the arrival time of the 16 November CME means that therefore REFM is not likely to prove useful beyond the first 24 hours, although its trend is otherwise considered accurate.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	10	20
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Figure 6: GOES16 Electron Flux over past 24 hours

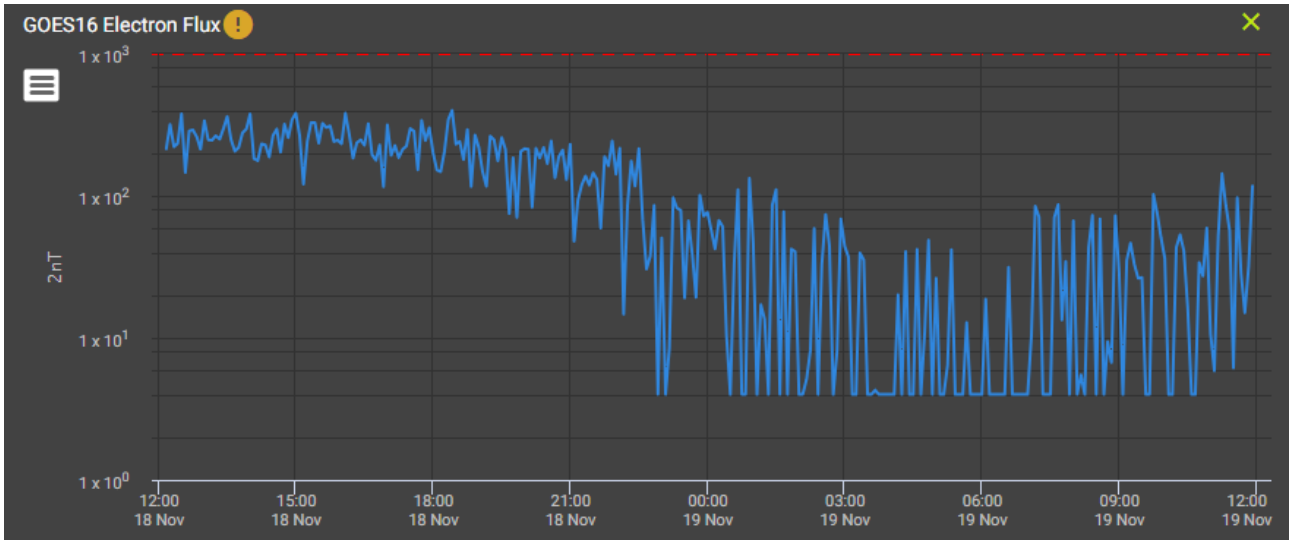
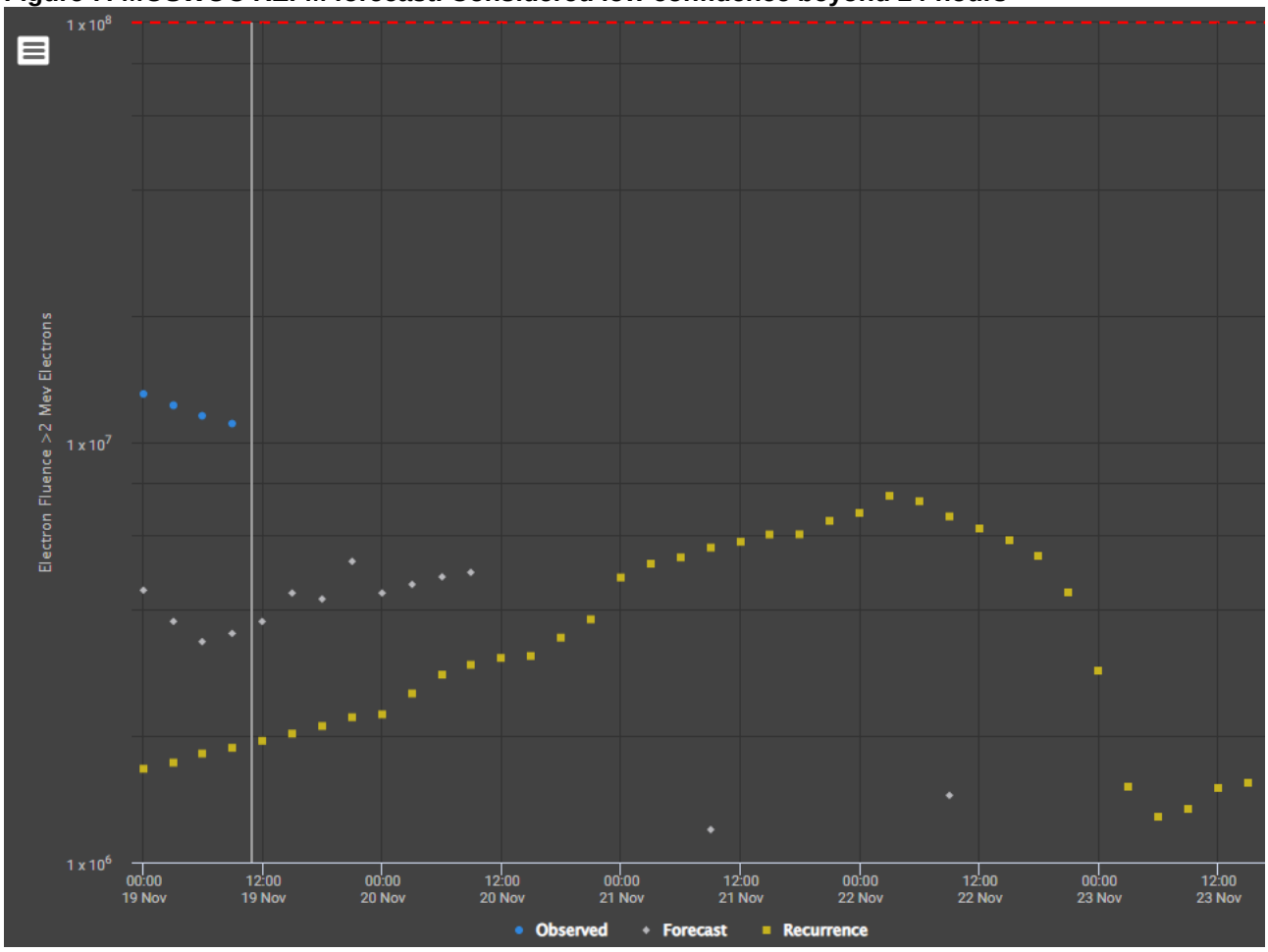


Figure 7: MOSWOC REFM forecast. Considered low confidence beyond 24 hours



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.